Strengthening the Emphasis on Numeracy in Career and Technical Education

Technology Centers That Work (TCTW)

1st Two Day Session ~ October 14-15, 2009

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The new mission of high school career/technical studies is to help students complete a program of study that prepares them for both employment and further postsecondary training or study. With this new mission comes the responsibility of the career/technical teacher to increase academic achievement of all students, to ensure students are technically literate and to ensure students can continue to learn in a career and in postsecondary education. This calls for a transformation in both what and how we teach in high school career/technical studies.

This workshop will focus on building the ability of career/technical teachers in trade and industry clusters to enhance their students' mathematical or "quantitative" literacy. Career/technical teachers will examine the mathematics they already teach in their programs and find ways to bridge the knowledge and skills from the mathematics classroom into more rigorous mathematics in the career/technical classroom. This workshop will place teams of CTE teachers from like clusters into professional learning communities focused on enhancing current instruction with rigorous mathematics. Participants will evaluate sample project units for mathematics possibilities and will consider ways to revise and enhance projects and assignments they are currently teaching to include rigorous mathematics

Workshop Objectives: As a result of this workshop, participants will:

- determine what will be required for career/technical students to demonstrate their understanding of mathematical concepts and skills necessary for entrance into the workforce, for advancement in the workforce and for entry into postsecondary training or study;
- investigate myths about students who struggle with learning mathematics and learn how embedding mathematics in career/technical instruction is a source for helping students overcome math anxiety;
- examine SREB's Postsecondary Readiness Indicators for mathematics;
- examine sample C/T project units for evidence of embedded numeracy;
- develop teacher assignments and instructional materials, and identify related study materials that enhance mathematical learning related to projects and assignments in career/technical courses;
- develop activities and assignments that require students to work through mathematics examples embedded in the CT curriculum, planned projects and assignments.

AGENDA

October 14, 2009:

9:00 a.m. - 9:45 a.m.	**Welcome, Introductions and Orientation to Workshop Objectives ~** Warm up our Math Minds!
9:45 a.m. – 10:15 a.m.	**Numeracy ~ Broadening the View of "Quantitative Literacy"**

10:15 a.m.-11:00 a.m.	**Keeping the End in Mind: High-wage, High-demand, High-skill Jobs and Postsecondary Training/Study** Participants will examine their role in providing opportunities for trade and industry career/technical students to improve mathematical or "quantitative" literacy.
11:00 a.m. – 11:15 a.m.	**Break**
11:15 a.m.- 12:15 p.m.	**Mind Mapping the Current State of Numeracy** Career/technical teachers will participate in a brainstorming activity in which they identify the mathematics content and processes they already teach within their programs and the mathematics students need in order to be successful in an entry-level job, in advancement in their careers and in postsecondary training and study.
12:15 p.m. –1:15 p.m.	**Lunch**
1:15 p.m.-2:00 p.m.	**A Comparison of our Current State to Mathematics Standards** Career/technical teachers will look at SREB's indicators for postsecondary readiness in mathematics, the South Carolina mathematics standards, National Council for Teachers of Mathematics standards, and the knowledge and skills statements from the States' Career Cluster Initiative. Participants will compare their lists produced before lunch and begin to examine possibilities for expanding the mathematics they already teach within their program areas.
2:00 p.m. – 3:45 p.m.	**What does "Mathematics Readiness" Really Mean?** Participants will team up to develop an experiential teaching lesson around one of several mathematics "power standards". Lessons will engage peers as students-of-numeracy. (includes rolling break)
3:45 p.m.-4:00 p.m.	**Reflections on the Day, Homework and Adjourn**

<u>October 15, 2009</u>:

9:00 a.m.-9:45 a.m.	**Welcome, Introductions and Orientation to Day Two Objectives ~ Warm-up those Numeracy Minds!**
9:45 a.m.-10:15 a.m.	**Reflections from Day One** Participants will share their experiences with embedding numeracy homework and gear up for lesson techniques
10:15 a.m.-11:00 a.m.	**The Power of the Cycle of Learning**

	Participants will use a literacy strategy to review the stages of a research-based lesson approach while examining a sample lesson
11:00 a.m.-11:15 a.m.	**Break**
11:15 a.m. -12:15 p.m.	**The Seven Elements of a Mathematics-Enhanced Lesson** Participants will examine a research model for embedding mathematics into CTE lessons and determine an approach to coordinating each step with the Cycle of Learning
12:15 a.m.-1:15p.m	**Lunch**
1:15 p.m. -2:00 p.m.	**Lesson Development for Modeling Mathematics Enhancement** Participants will develop a model lesson that reflects the seven elements and includes contextual examples. Peer review will provide feedback in preparation for session homework
2:00 p.m.-2:30 p.m.	**Numeracy Strategies for the Classroom** Teachers will participate in a series of numeracy strategies that can be reproduced in the career/technical classroom.
2:30 p.m.-2:45 p.m.	**Break**
2:45 p.m.-3:45 p.m.	**Developing a Career/Technical Project/Lesson for Classroom Use** Participants will select lessons/projects they will teach in the next 16 weeks and begin to develop a set of lessons designed to enhance students' mathematics achievement.
3:45 p.m.-4:00 p.m.	**Reflections on the Day, Homework and Adjourn**

Detective warm-ups ~ Area for jotting clues…

Definitions of Numeracy

SREB's working definition:

Numeracy, also called "quantitative literacy" encompasses a range of skills and attitudes. Numeracy includes:

- The ability to interpret and understand numeric symbols and relationships
- The ability to communicate and represent mathematics concepts in a variety of ways
- The development of mathematical culture and way of thinking and looking at the world in a mathematical way
- Appreciation for aesthetics, history, and application for math

Those who lead the school in promoting numeracy must understand numeracy. They must be able to see and explain how understanding quantities can help us in everything from knowing how to interpret poll results to being able to determine which health insurance policy we should buy.

Ideas for your definition:

The What and How of Numeracy

Take a moment and assimilate beta from your discussions, example definitions and your previous knowledge…

In your experience, what is one common misconception about numeracy?

What are consequences of innumeracy you have witnessed?

"According to NCTM, the key characteristics of high-quality mathematics instruction are:

- Teachers should encourage and inspire every student to continue the study of mathematics.
- Lessons balance and connect conceptual understanding and procedural and computational proficiency.
- Lessons use problem solving to understand our world.

- Teachers have solid knowledge of both content and teaching strategies.
- Teachers enjoy math.
- Students are actively engaged in the learning process.
- Students reason and make conjectures about problems.
- Students communicate their mathematical thinking orally and in writing.
- Students listen and react to others' thinking and solutions to problems.
- Teachers and students use a variety of representations, such as pictures, tables, graphs, and words, for their mathematical understanding.
- Teachers choose "good" problems—ones that invite exploration of an important mathematical concept and allow students the chance to solidify and extend their knowledge.
- Teachers assess students' understanding by listening to discussions and asking students to justify their responses.
- Everyone in school community is committed to numeracy.
- Students master the following five "strands:" Understanding, computing, applying, reasoning, and engaging.

Transforming Mathematics Content

Area of mathematics	Traditional perspective	Mathematical literacy perspective
Arithmetic	Adding, subtracting, multiplying, dividing	Units and conversions, measurements and tolerances, estimates and accuracy
Numbers	Place value, digits	Notation and coding, index numbers and averages, employment indices
Geometry	Properties of circles, triangles, areas and volumes	Shapes and measurements in three dimensions, using dimensions to organize data, global positioning systems
Statistics	Means, medians, standard deviations	Visual displays of quantitative ideas, random trials, confidence intervals
Logic	Mathematical rigor, deductive proof	Hypotheses, conjectures, causality and correlation, statistical inference
Probability	Calculating combinations	Estimating and comparing risks, chance and randomness
Applications	Solving word problems	Collecting, organizing and interpreting data; allocating resources and negotiating differences
Proof	Logical deduction	Counterexamples, scientific reasoning, legal standards, beyond a reasonable doubt
Technology	Doing arithmetic on calculators, creating graphs	Spreadsheets, statistical packages, presentation software, Internet

(Adapted from Steen)

Sources of good problems:

- *Developing Mathematical Reasoning in Grades K-12* edited by Lee Stiff. This is the 1999 yearbook from NCTM available at www.nctm.org.
- *Can Students Do Mathematical Problem Solving?* Results from constructed-response questions in NAEP's 1992 mathematics assessments. For more information, visit online at http://nces.ed.gov
- *Why Numbers Count*, by Lynn Arthur Steen. Available from the College Board.

Exploring Numeracy by Keeping the End in Mind

What mathematics content and processes is already addressed in CT program

What mathematics skills students need in order to be successful in an entry-level job

Career Cluster: _____

What mathematics skills students need to advance in their careers and in postsecondary training and studies

Exploring Numeracy by Keeping the End in Mind!

This collaborative activity asks you to form a cluster team, study one of the Career Clusters areas in depth, and create a poster illustrating key aspects of numeracy. Then, each group will report out their findings so that everyone can gain an understanding of the numeracy skills needed for career and post-secondary success.

TASK 1: STUDY A CAREER CLUSTER

- After introductions, each describe the "content" of your CT program courses
- Identify the mathematics skills and procedures already addressed through your coursework ~ record a list on previous page.
- Brainstorm what mathematics skills and procedures are needed for success in an entry-level job, advancement in a career and postsecondary training and studies. ~ Record your thoughts on previous page.

TASK 2: CREATE A "NUMERACY-BY-CLUSTER" POSTER

Each team numeracy-by-cluster poster should include the following:

- A **title** to identify career cluster/occupational areas.
- A **description** of career cluster occupations ~ what is included…
- A **list** of the National Council of Teachers of Mathematics (NCTM) "Process Standards" that appear on any of your lists (i.e. Problem Solving; Reasoning and Proof; Communication; Connections; and Representations)
- Lists of math skills that appear on any of your lists---categorized by the following headings: Numbers & Operations; Algebra; Geometry; Measurement; and Data Analysis and Probability (feel free to use the chart on the following page to organize your lists.)
- A **logo** or symbol for your Numeracy-by-cluster poster!

TASK 3: PRESENT THE POSTER

- Once your poster is complete, prepare to present your poster to the rest of the room.
- You'll only have a minute or two to present –make sure you're concise!

College and Career Readiness Indicators
~ POWER STANDARDS ~
for Mathematics Content Standards

Use the chart below to organize your skills lists for your Numeracy-by-cluster poster…

Numbers and Operations	
Algebra	
Geometry	
Measurement	
Data Analysis and Probability	

All Aspects of an Industry

When career/technical programs of study programs address the following nine aspects of an industry, students gain a better understanding of the industry and are better prepared to enter it.

Planning — examined both at the industry level and at the firm level; various forms of ownership, including cooperatives and worker ownership; relationship of the industry to economic, political, and social context
Management — methods typically used to manage enterprises over time within the industry; methods for expanding and diversifying workers' tasks and broadening worker involvement in decisions
Finance — ongoing accounting and financial decisions; different methods for raising capital to start or expand enterprises
Technical and production skills — specific production techniques; alternative methods for organizing the production work, including methods which diversify and rotate workers' jobs
Underlying principles of technology — integrated study across the curriculum of the mathematical, scientific, social, and economic principles that underlie the technology
Labor issues — worker rights and responsibilities; labor unions and labor history; methods for expanding workers' roles
Community issues — the impact of the enterprise and the industry on the community, and the community's impact on and involvement with the enterprise
Health, safety, and environmental issues — in relation to both the workers and the larger community
Personal work habits — involves the non-technical skills and characteristics, such as work ethic, that are expected in an employee

Sources:
1) Andrew, Tammy. "Teach Workplace Expectations: How All Aspects of the Industry Prepares High School Students," May 19, 2008 — http://high-school-curriculum.suite101.com/article.cfm/teach_workplace_expectations.
2) Clay, Ben. *All Aspects of a Business, Industry, Company.* Kansas Competency-Based Curriculum Center, 2002.

SREB's Mathematics Readiness Indicators for Postsecondary Studies and Careers

1. Solve real-world problems using appropriate solution strategies.
2. Use the language of mathematics to explain thinking processes and communicate solutions within a context.
3. Use a variety of techniques to recognize correct answers, check for reasonableness and identify mistakes.
4. Formulate conclusions, construct arguments and make conjectures based on observations.
5. Use technology (including software and graphing calculators) to enhance understanding of mathematical ideas and concepts.
6. Identify and describe differences among natural numbers, whole numbers, integers, rational numbers and irrational numbers.
7. Solve problems involving positive integer exponents, scientific notation, numerical factors, least common multiples, square roots and cube roots.
8. Use proportional reasoning to model and solve application problems involving rate, indirect variation, direct variation, scale drawings and similar figures.
9. Read, analyze and convert various measures given within application settings, including multi-step conversions.
10. Use multiple pieces of data from multiple data representations to calculate and solve problems.
11. Solve one- and two-step equations and inequalities in one variable, including word problems.
12. Determine the equation of a line and represent the equation in a variety of ways (including slope-intercept form, standard form and point-slope form).
13. Identify and factor polynomials including trinomials, perfect squares, difference of two squares and polynomials with common factors.
14. Analyze, interpret and solve systems of equations or inequalities with and without technology.
15. Model and solve problems involving non-linear functions using technology.
16. Translate among tabular, graphical and algebraic representations of non-linear functions.
17. Compare and contrast the characteristics of non-linear function families with and without technology.

Exploring Mathematics Readiness…team challenges!

Directions: Read the section of the *SREB Postsecondary Readiness Guide: Senior Applications of Mathematics* that pertains to your team's assigned Indicator. Your challenge is to create a "mini lesson" that will involve your peers in exploring the indicator. Design an activity that will allow participants to experience the indicator. Feel free to include sample assessment questions… be creative in your set-up… can be an authentic life situation, or from someone's CTE area… have fun!

Prep Time: 1 hour

Mini Lesson Time: 20-25 min.

Mini Lesson Planning Area

Exploring Mathematics Examples of a career/technical project that is rich with embedded mathematics content

SAMPLE PROJECTS

Georgia: Gadgets and Gizmos (pre-engineering mechanical drawing)
After studying the components of a Request for Proposals (RFP) in a pre-engineering mechanical drawing class, students working in groups will invent a gadget or gizmo, create an RFP a company might submit to them for that gadget or gizmo, and produce technical drawings for said gadget or gizmo which meets the requirements of the RFP. Students will individually submit a three-page essay describing the use of mathematics in the technical drawings and in the bid proposal, including identification and use of special right triangles, the properties of circles and a description of how they applied appropriate mathematical strategies to solve problems related to the project.

Alabama: Compressed Air Systems (collision repair)
Working in groups students design a Collision Repair Shop ensuring the installation of an adequate and precise compressed air system based upon the number of employees working in the shop. Groups will produce a scale drawing, including a plan for installing a sufficient compressed air system. Following experiments for understanding of psi including weight of pressure from scale and hand trace area, eagle gripping strength, hose diameters and hand windmills, students will prepare a mock run of air lines for their shop design and make presentations to the class, including use of appropriate technical and mathematics vocabulary. Individuals will submit a research paper describing the types of air compressors and demonstrating an understanding of the relationship between horse power, pounds per square inch, and cubic feet per minute. Project design will include graphing a comparison of psi to cfm or hp to psi or cfm. to explain the increase or decrease in each according to shop design and/or job performed and tools used at the same time.

Alabama: I Designed It. Now Build It! (PLTW Introduction to Engineering)
After learning how to sketch isometric, oblique and multi-view drawings, beginning pre-engineering students create an original object and create isometric, oblique and multiview drawings of the object. Student drawings are assessed by a peer who builds the object from Legos, blocks or found materials. In order to demonstrate understanding of unit measurement and line conventions, students are required to create and describe the unit of measurement which will be used by the peer to construct the original object (Students are not allowed to use standard units of measure like millimeter or inches.). Students complete an engineering notebook documenting rough sketches and brainstorming of ideas, sketches (isometric, oblique, multiview), constructed object and written summary.

North Carolina: The Doctor is Not In (Health Sciences Pre-Nursing Program)
In medical facilities as well as home care the vitals signs, height, and weight are measured to monitor the health of patients when physicians are not present. Accurate medical charts must be maintained and monitored for adequate health care. Working in groups students will study the health and monitoring needs of four hospital patients in order to design a role playing exercise. In rotation, students will serve as patients whom the rest of the class will monitor and observe, maintaining patient charts, charting vital signs, simulated input and output of fluids, intake of food and fluids. Students are responsible for creating a patient chart, including charts and graphs from the monitoring and written reports to the physician describing patient health which include mathematically communicating rate of change in observed data and central tendencies using appropriate mathematical and medical vocabulary.

Texas: Design and Build a Lifting Device (Pre-Engineering)
Students in a special employment program for special needs at Texas High School, Anytown, TX run a school-wide paper recycling project. The problem is they must lift papers from a 326 pound container into a dumpster. In order to make this job easier for the physically disabled students, you will work in groups to design a mechanical lift to dump the 326 pound containers into the dumpster. You will make use of geometric concepts such as triangle similarity, trig, ratios, solid figure similarity, angle relationships, properties of plane and solid figures, congruent figures and the Pythagorean Theorem. The mechanical, or physics, concepts include force, mass, friction, velocity and acceleration, Newton's second law, dynamics, and pendulum motion. In order to use these mechanical concepts in completion of the lift, students must also understand how to solve proportions, equations, and summations. Using these geometric and mechanical concepts, you will design and produce technical drawings in Auto CAD. You will then build models and a prototype of a pneumatic lift ladder with a rolling slide and mechanical gears. Since the biggest concerns in this project is cost and safety, the design must include considerations for keeping the container secure on the lift and build a receptacle latch and safety locking devises. Members of the business community will advise you, and field trips will be made to NASA Behind the Scenes, the Houston Natural Science Museum, and KBR Engineering to assist in the design process.

Alabama: Designing a Food Plot (Agriculture)
Learning to manage wildlife by planting food plots, creating areas for cover and providing water and arrangement is an important skill for successful agriculture management. In this project, you will use technical and academic knowledge and skills to design a scale model of a food plot including the preparation of a budget for creating the plot and justifying the importance of the plot as it relates to the costs of managing crop acreage. Select and research the wildlife you intend to target, determine the size of the food plot needed by the wildlife and best practices in the technical field. Research should also include best practices in providing cover, water and arrangement of plot components. Contact the local coop to determine food and fertilizer prices. You are required to show all mathematics used in producing the scale model, including ratio and proportions and equations used for calculating food plot costs. Submit an essay justifying the expense of your food plot based upon the proportion of your land used for the food plot.

Illinois: Transportation and Logistics (This is a project idea from the state's website at www.tdlmathscience.org.)

Dot Foods would like to add a new distribution center. It currently has distribution centers in Modesto CA, Dallas TX, Ardmore OK, Chesterfield MO, Vidalia GA, Williamsport MD, Liverpool NY and Chicago IL, with corporate headquarters in Mt. Sterling IL. This new distribution center will create a need to realign customer delivery areas. Your job will be to

decide which customers will be supplied by each distribution center. The solution should be based on minimizing the transportation and distribution cost required to move the product. Students prepare a business report with a cover letter, introduction stating the purpose of the report, documentation to support recommendations, detailed explanation of costs and charts and tables represented through spreadsheets to clearly communicate the recommended distribution plan. Students will also prepare a business presentation with appropriate visual aids. Student project portfolio will also include a section detailing algebraic formulas used (transportation cost, handling and storage costs, local/regional distribution costs, calculation of possible permutations of locations).

Using the assigned sample project ideas, decide as a table team the following:

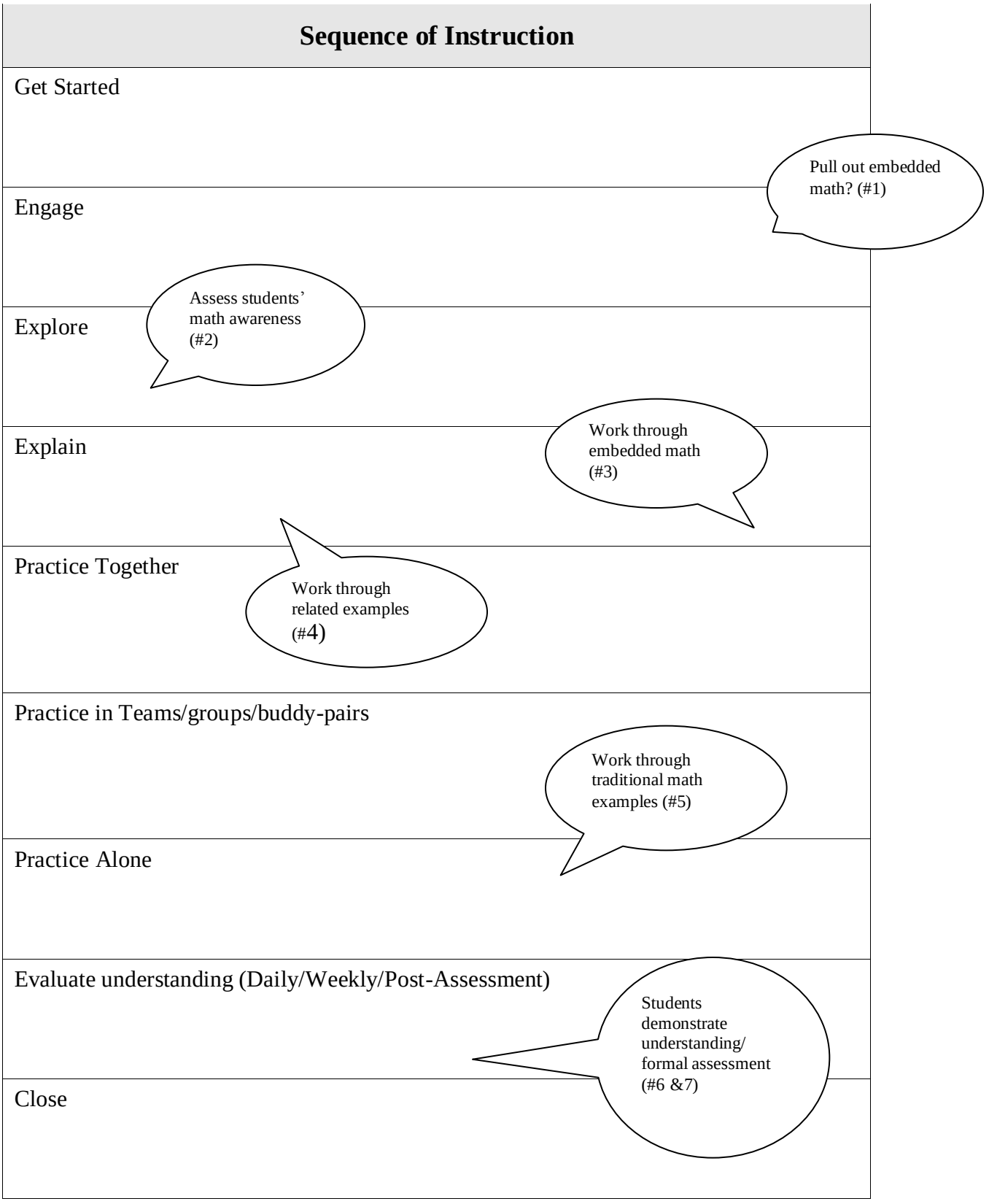
A. Is this problem/project authentic to the field?
B. What mathematics PROCESS standards are evident?
C. Are students required to use mathematics at a higher level than middle school and arithmetic?
D. What would improve this project?

The "Seven Elements" of a Math-enhanced CTE Lesson

1	**Introduce the CTE lesson.** Explain the CTE lesson. Identify, discuss, point out, or pull out the math embedded in the CTE lesson.	Make the objective of the lesson explicit. Do not introduce as a "math" lesson. Discuss/share introductory approaches at your PD sessions.
2	**Assess students' math awareness as it relates to the CTE lesson.** As you assess, introduce math vocabulary through the math example embedded in the CTE. Employ a variety of methods and techniques for assessing awareness of all students, e.g., questioning, worksheets, group learning activities, etc.	Bridging of CTE content to math vocabulary should begin here. During PD sessions, share and/or develop methods for assessing awareness. Involve all class members in assessment.
3	**Work through the math example *embedded* in the CTE lesson.** Work through the steps/processes of the embedded math example. Bridge the CTE and math language. The transition from CTE to math vocabulary should be gradual throughout the lesson, being sure never to abandon completely either sets of vocabulary once it is introduced. Examples:	Use aids that illustrate the concepts and vocabulary. Examples: Posters PowerPoint presentations Handouts Resources
4	**Work through related, contextual math-in-CTE examples.** Use the same math concepts embedded in the CTE lesson: Work through similar problems/examples in the same occupational context. Use examples with varying levels of	Develop examples of various levels of difficulty. Develop separate worksheets for the various levels. Locate/utilize resources that support bridging of vocabulary.

	difficulty; order examples from basic to advanced. Continue to bridge CTE and math vocabulary. Check for understanding.	
5	**Work through *traditional* math examples.** Use the same math concept as in the embedded and related, contextual examples: Work through traditional math examples as they may appear on tests. Move from basic to advanced examples. Continue to bridge CTE and math vocabulary. Check for understanding.	Use samples from: Standardized tests State tests Develop worksheets and create learning activities.
6	**Students demonstrate their understanding.** Provide students opportunities for demonstrating their understanding of the math concepts embedded in the CTE lesson. Tie the math examples back to the CTE content; conclude the lesson on the topic of CTE.	Develop learning activities that allow students to demonstrate their understanding of both the math and the CTE lesson.
7	**Formal assessment.** Incorporate math questions into formal assessments at the end of the CTE unit/course.	Include math questions on any regularly-scheduled testing or unit exams. Include math assessment as a part of major projects.

The Cycle of Learning ~ Numeracy-Style!



Unit Plan Template for Daily Lessons

Day _____ of _____

Readiness Indicator(s) for Today's Activities # ____ # ____	Description
State/District Standard(s) for Today's Activities # ____ # ____ # ____ # ____ # ____ # ____	Description

Anticipated Times * (90-minute Block Schedule)	Sequence of Instruction	Activities Checklist
____ minutes (3)	Get Started	___ Admit slip ___ Post/discuss/copy objectives ___ Write in journal ___ Solve problems ___ Answer questions ___ Pre-assessment ___ Other _____
____ minutes (5)	Engage	___ Display object/picture ___ Demonstrate reaction ___ Model/demonstrate lab ___ Discuss previous experiences ___ Other _____
____ minutes (15)	Explore	___ Brainstorm ___ Create lists ___ Investigate ___ Build a model ___ Work problem ___ Analyze data ___ Evaluate steps ___ Lab activity ___ Other _____
____ minutes (15)	Explain	___ Lecture with guided notes ___ Student presentations ___ Media presentation ___ Interactive discussion ___ Other _____
____ minutes (10)	Practice Together	___ Complete practice problems/labs ___ Use manipulatives ___ Construct graph/timelines

		___ Make predictions ___ Collaborative writing ___ Whole group graphic organizers ___ Other _____
_____ minutes (10)	Practice in Teams/groups/buddy-pairs	____ Solve similar problems ____ Practice active reading strategies ____ Answer questions ____ Peer review/edit ____ Design other problems/questions/labs ____ Research information ____ Other _____
____ minutes (10)	Practice Alone	____ Draft writing ____ Answer questions/problems ____ Design/construct other problems/ questions/labs ____ Revise work ____ Design individual investigation/project ____ Other _____
____ minutes (15)	Evaluate understanding (Daily/Weekly/Post-Assessment)	____ Discussion ____ Open-response question(s) ____ Quiz/test (academic/authentic) ____ Writing sample ____ Individual project/investigation/ presentation ____ Other _____
____ minutes (5)	Closing Activities	____ Assign/explain homework ____ Review major points ____ Answer questions ____ Student reflection activity ____ Exit slip ____ Other _____
____ As Needed	Enrichment/Extension/Re-teaching/ Accommodation(s)	____ Review ____ Practice ____ Reading ____ Tutoring ____ Individual assignment ____ Other _____

Resources/Instructional Materials Needed:

Tools for Enhancing Mathematics in CTE Projects and Lessons

- **T-Chart:** PA teacher-developed tool to outline associated vocabulary, visuals, descriptions and example test problems (see handout template and carpentry example)

- **Writing Authentic & Contextual Problems:** guidelines, example problems and a template to guide development

- **RAP Sheet**: helping students with reading and writing mathematics problems; an example and a template

- **Higher-order Questioning**: Definitions, examples, and a Q-chart to develop a variety of questions throughout a lesson

- **Literacy Strategies**: several usable strategies to enhance vocabulary use and understanding that can be incorporated into lesson planning

Comparison of Contextual and Standardized Test Items

While developing assessment and pre-assessment items in mathematics, include both contextual and standardized test items. See samples below.

Problem Solving

- Authentic Assessment-Mechanics are sometimes paid by the "salary plus commission" method. Suppose a mechanic is paid a base salary of $260 a week plus 15% of all sales over twice his base salary. How much in sales must the mechanic generate in order to receive a gross salary of $300?

- Non-Authentic Assessment-Ms. Lewis plans to drive 900 miles to her vacation destination, driving an average of 50 miles per hour. How many miles per hour faster must she average, while driving, to reduce her total driving time by 3 hours?

Vocabulary

- Authentic Assessment-A hill on a highway has a grade of 3:2. What is the rise for ½ mile of highway?

- Non-Authentic Assessment-A circular coin has a radius of 3/8 inch. When lying flat, how much area does the coin cover, in square inches?

Evaluating Results

- Authentic Assessment-Uptown Cable, a cable TV provider, charges each customer $120 for installation, plus $25 per month for cable programming. Is the following equation for calculating the cost for the first 6 months correct? If not, make corrections.
  6($120+$25)=cost for first 6 months

- Non-Authentic Assessment-If x is a real number greater than 1,000,000, which of the following fractions is the smallest in value?

F. $\frac{5}{x+1}$ **G.** $\frac{x+1}{5}$ **H.** $\frac{5}{x-1}$ **J.** $\frac{5}{x}$ **K.** $\frac{x}{5}$

Reasoning

- Authentic Assessment-The figure below is the path that a robot will travel from point A to B. Write directions, using ordered pair coordinates, for shortest distance the robot must travel.

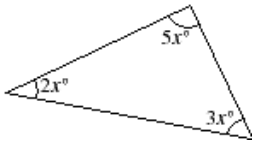
- Non-Authentic Assessment -If n is an odd positive integer, which of the following is an even integer?

A. $(n+1)2-1$ B. $2n2$ C. $2n2-1$ D. $2n-1$ E. $3n$

Ratio and Proportion

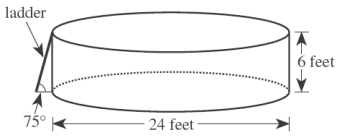
- Authentic Assessment-A scale drawing of a rectangular room is 5 inches by 3 inches. If 1 inch on this scale drawing represents 3 feet, what are the dimensions of the room?

- Non-Authentic Assessment-The measures of the angles of a triangle are in the ratio of $2x$: $3x$: $5x$ as illustrated below. What is the measure of the smallest angle in the triangle?



Measurement

- Authentic Assessment-The youth center has installed a swimming pool on level ground. The pool is a right circular cylinder with a diameter of 24 feet and a height of 6 feet. A diagram of the pool and its entry ladder is shown below. To the nearest cubic foot, what is the volume of water that will be in the pool when it is filled with water to a depth of 5 feet? (Note: The volume of a cylinder is given by $\pi r^2 h$, where r is the radius and h is the height.)



- Non-Authentic Assessment-The edges of a cube are each 3 inches long. What is the surface area, in square inches, of this cube?

Using Data

- Authentic Assessment-Tom's long-distance service charges $0.10 per minute from 7:00 P.M. to 7:00 A.M. on weekdays, all day on Saturdays, and all day on holidays; $0.05 per minute all day on Sundays; and $0.25 per minute at all other times. The table below gives his long-distance calls for 1 week, including the date and day of each call, the time it was placed, and the number of minutes it lasted.

Date and day	Time	Number of minutes
11/22 Tuesday	5:00 P.M.	8
11/23 Wednesday	10:30 A.M.	10
11/24 Thursday Thanksgiving holiday	11:30 A.M.	15
11/26 Saturday	9:30 A.M.	17
11/27 Sunday	12:15 P.M.	22

- Non-Authentic Assessment-What is the median of the following 7 scores? 42, 67, 33, 79, 33, 89, 21

Linear Equations and Inequalities

- Authentic Assessment-Two enterprising college students decide to start a business. They will make up and deliver helium balloon bouquets for special occasions. It will cost them $39.99 to buy a machine to fill the balloons with helium. They estimate that it will cost them $2.00 to buy the balloons, helium, and ribbons needed to make each balloon bouquet. Write an expression that could be used to model the total cost for producing b balloon bouquets?

- Non-Authentic Assessment-The inequality $3(x + 2) > 4(x – 3)$ is equivalent to which of the following inequalities?

F. $x < –6$ **G.** $x < 5$ **H.** $x < 9$ **J.** $x < 14$ **K.** $x < 18$

Nonlinear Functions

- Authentic Assessment-A company that manufactures cardboard boxes is using stock material that is 18 inches wide. Write an equation that can be used to calculate the area of the end of the box when different length sides are turned up from the 18 inches. Use a graphing calculator to determine the amount to turn in order to get the maximum area for a label at the end of the box.

- Non-Authentic Assessment-If one leg of a right triangle is 8 inches long, and the other leg is 12 inches long, how many inches long is the triangle's hypotenuse?

Representations of Relationships

- Authentic Assessment-The town of Mayville taxes property at a rate of $42 for each $1,000 of estimated value. Create a tax chart that can be used by citizens to calculate the amount of tax they owe. What is the estimated value of a property on which the owner owes $5,250 in property tax?

- Non-Authentic Assessment-If $f(x) = x2 – 2$, then $f(a + 2) = ?$

Where can we find good examples of assessment items?

- Released NAEP items: http://nces.ed.gov/nationsreportcard/nde and http://nces.ed.gov/nationsreportcard/itmrls/startsearch.asp
- State accountability tests-released items
- SkillsUSA test items : http://skillsusa.org/compete/math.shtml
- Textbooks (enrichment sections)
- Sample mathematics found in careers and industry www.micron.com/k1

Micron Problem from BOISE POLICE DEPARTMENT: Law Enforcement-Police Officer

Background:

A car travels 1.467 feet per second for every 1 mph.

The formula for speed (in miles per hour) is $S = \sqrt{30fd}$.

Feet per second (fps) = miles per hour (mph) x 1.467

Total Stopping Distance = (reaction time) x (fps) + skid length

d=Distance traveled

$$\text{Time} = \frac{d}{v}$$

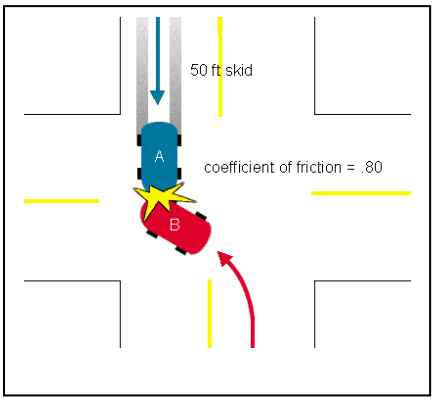
Questions:

1. Assuming a reaction time of .75 seconds, how fast was car A traveling at the beginning of its skid? The coefficient of friction (f) on the road is .80. The coefficient of friction is given for different circumstances, such as dry pavement, snow floor, or black ice.

2. What was the total stopping distance of car A?

3. How long did it take car B to turn if driver A reacted immediately when car B began its turn?

http://www.micron.com/k12/math/algebra/police.aspx



Guidelines for Developing Authentic Problems *©CORD2002-John Chamberlain*

1. **Apply desired math content.**
   The primary goal is to flex the student's thinking concerning one or more particular mathematics concepts. At some point in the solution to the problem, students must apply the desired math concept. Ideally, other recently learned topics should also be used to reach the solution.

2. **Use a non-contrived scenario.**
   Always ask yourself, "Would anyone ever need to actually do this? And if so, in what sort of circumstance?" The contextual problem should then briefly present that circumstance in support of the problem. Avoid manipulations that produce an opportunity to apply a mathematical technique to retrieve a solution, but in reality, would *never* occur in real life. For example, while an obvious algebra application, no one would ever really confront the following contrived problem: "The total of two employees' salaries is $135,000. If the first earned twice as much as the latter, what is each of the salaries?"

3. **Include real-world numbers with appropriate units of measure.**
   Whenever possible, use real-world numbers with real-world units of measure. Avoid always using integers and values that result in integers, especially in applications for which integers are atypical. Real-world numbers frequently come from measurements, and so the units of measure should be a meaningful part of the given data as well as the answer being sought. Use measures that are typical for the scenario being described. For example, a pipe size would generally be given in inches of outside diameter, not centimeters of inside radius.

4. **Remain faithful to the selected occupational area.**
   Refer to workers, occupations, and situations that would inhabit your problem scenario. Ethnic and gender diversity will help more students to identify with the problem. Be careful that the problem represents situations that could really occur in that workplace scenario.

5. **Include some extraneous data.**
   To solve most real-world problems, we must sift through all the facts surrounding a situation to distill the pertinent data. Good contextual problems often include at least one piece of irrelevant, but meaningful, information.

6. **Avoid hand-holding or step-by-step guidance.**
   While helpful for elementary contextual problems, better problems should not include step-by-step guidance to achieve the desired solution. Rather, the given information should be presented in a way similar to how it would be encountered in real life, and the question or goal clearly stated. The student should be able to use the various supplied data and facts, along with the appropriate math concepts to achieve a solution.

Example Exercises in Information Technology	Concerns
Original version: Carlos has an annual budget of $7500 to purchase special software packages for the Accounting, Sales, and Purchasing Departments. He allocates his funds evenly among all three departments. If the Sales Department has already spent $723.87, how much more can they expend without exceeding the budget? **Revised version:** Carlos is the Network Administrator and must allocate maximum disk space values to the various workgroups in the company. The total space used by all the groups can only reach 90% of the drive's total capacity of 750 gigabytes, to allow a 10% pad for file compression space. Based on past experience, Carlos will allocate an equal share to the Engineering, Research, and Human Resources groups. But, the Accounting and Payroll groups each require twice the normal share, and the Marketing group with all their graphic design work requires five times the normal share. Write an equation that expresses these relationships and determine how much disk space allocation each group should receive. ***Solution:*** Let x be the smallest share, for example, given to Engineering. $0.90\ \ 750\ \text{GB} = x + x + x + 2x + 2x + 5x$ $675\ \text{GB} = 12x$ $56.25\ \text{GB} = x$ 56.25 GB for Engineering, Research, and Human Resources 112.5 GB for Accounting and Payroll 281.25GB for Marketing	1) This is more an Accounting problem than an IT problem. 2) This is a contrived situation. If anyone knows the annual budget for the three departments, they'd also know the annual budget for the Sales Dept, and hence, would immediately know how much is left after spending $723.87. **Suggested changes:** • Include job title. • Mention computer hardware familiar to students. • Use values typical to real world. • Require writing an equation from a problem situation. • Require answers that would actually be required of Carlos.
Original version: Bart is the line supervisor for a company that produces silicon chips. The line can produce 300 chips in 50 minutes. At this rate, how many can be produced in 85 minutes? **Revised version:** Bart is the line supervisor for a company that produces silicon chips. A new automatic tester just installed on Line 5 was able to test 180 chips in the first 30 minutes of clean operation. The old testers typically tested about 2950 chips in an 8-hour shift. How does the rate of the new tester compare to the old tester? How many chips should Bart expect the new tester to produce in an 8-hour shift? **Solution:** Since 8 hours = 8 hours $\times$ 60 $^{\text{min}}\!/_{\text{hr}}$ = 480 minutes,	1) This problem needs a "bit more" to give it credibility with students. As written is sounds contrived. 2) Little association with IT beyond the words "silicon chips." 3) Why would Bart need to know how many chips can be produced in 85 minutes? **Suggested changes:** • Include a piece of high-tech equipment by name: a tester • Use a time period that might really be used as a first measurement: a half

Example Exercises in Information Technology	Concerns
$$\frac{180 \text{ chips}}{30 \text{ minutes}} = \frac{x}{480 \text{ minutes}}$$ $$30 \text{ minutes } x = 180 \text{ chips } 480 \text{ minutes}$$ $$x = 2880 \text{ chips}$$ The new tester is performing a little slower than the old, at a rate of 2880 chips per 8-hour shift.	hour. • Ask for a comparison that would be meaningful to Bart: is it working faster than the old machine? • Ask for a value that would be meaningful to Bart: the production for an 8-hour shift.

CORD, 2002

Writing Authentic Problems	
CTE concept	
Math concept	
CTE Scenario	
Authentic Problem	
CTE concept	
Math concept	
CTE Scenario	
Authentic Problem	

RAP Sheet-Improving Reading and Writing Skills

RAP **Example and Template**. (10 point problem)

Mechanics are sometimes paid by the "salary plus commission" method. Suppose a mechanic is paid a base salary of $260 a week plus 15% of all sales over twice his base salary. How much in sales must the mechanic generate in order to receive a gross salary of $300?

RAP

READ	Read the problem carefully, all the way through. What key words are used, what are you asked to find and what information is given? Write each down.
__1__ points	Find– amount of sales in order to gross $300
__1__ points	Key Words– plus, gross, percent of, twice base, over
__1__ points	Information Given– $260 base salary, 15 percent of sales over twice salary, gross salary wanted is $300
ASK	Ask yourself how you will solve the problem. Write out your plan. Then write a verbal equation to reflect your plan.
__1__ points	Verbal Plan– Gross salary equals base salary plus 15% of sales over twice the base salary.
__1__ points	Verbal Equation– Gross = Base + .15(sales – 2 x Base)
PUT	Put mathematical symbols in your word equation. Solve the resulting Problem and check to see if the result I a reasonable answer for the question that was asked.
__2__ points	Variable Equation– Let x = amount of sales in $ $300 = $260 + .15[x – 2($260)]
__1__ points	Solving– $300 = $260 + .15[x – 2($260)] $300 = $260 + .15(x – $520) $300 = $260 + .15x - $78 $300 = $182 + .15x $786.67 = x
__1__ points	Answer– The mechanic must generate $786.67 in sales.
__1__ points	Reasonable? Why or Why Not?– Sales of $786.67 are reasonable for one week. The amount of this figure over $520 (twice the base salary) is about $250 and 15% of that is about $36, very close to the $40 needed to increase a salary of $260 to $300. The answer is reasonable.

RAP

READ	Read the problem carefully, all the way through. What key words are used, what are you asked to find and what information is given? Write each down.
_____ points	Find–
_____ points	Key Words–
_____ points	Information Given–
ASK	Ask yourself how you will solve the problem. Write out you plan. Then write a verbal equation to reflect your plan.
_____ points	Verbal Plan–
_____ points	Verbal Equation–
PUT	Put mathematical symbols in your word equation. Solve the resulting problem and check to see if the result is a reasonable answer for the question that was asked.
_____ points	Variable Equation–
_____ points	Solving–
_____ points	Answer–
_____ points	Reasonable? Why or Why Not?

What role does teacher questioning play in learning mathematics?

Research and Best Practice

Learning is maximized in classrooms where questions are encouraged, elaboration and explanation are expected, and feedback is frequent. In such classrooms, both large and small group discussions are prevalent, with interaction between teacher and students and among students.

Effective mathematics teachers (those who are highly rated by their students and whose students perform well on both content and problem-solving skills assessments) ask many questions of all types during their lessons. Compared to less effective teachers, they pose more questions with higher cognitive demand, and ask more follow-up questions. Their students ask more questions, as well. Effective teachers orchestrate productive discussion in classrooms. Students engaged in discussion are better able to make sense of ideas, create as well as demonstrate understanding, and reflect on their thinking. Questions can be used as an effective learning tool prior to a learning experience.

Students in high-performing and conceptually-oriented classrooms are expected to share ideas with others. Striving to explain their thinking helps students clarify their own ideas, even when their thinking is not totally clear, or their understanding is not well formulated. Students who must explain their thinking organize their thoughts differently, analyzing the strategies they employed by engaging in self-reflection and analysis.

Studies of questioning in typical mathematics classrooms confirm that most questions make minimal demands on student thinking. Low level questions include yes/no questions; guessing; simple recall of fact. formula, or procedure; leading or rhetorical questions; and those answered immediately by the teacher. Answers are often immediately judged right or wrong by the teacher, and discussion moves to the next question. Increasing the wait time between posing a question and expecting an answer increases the number of responses, student confidence, responses by less able students, and reflective responses.

Classroom Implications

Good questioning requires skill and planning. Strategies to improve questioning techniques include

- Plan questions while preparing lessons. Write out questions to launch a lesson, and compose clarifying questions to use during exploration.
- Choose different questions for varied purposes — clarifying questions, redirecting questions, summarizing questions, extension questions, and reflection questions.
- Tape lessons occasionally to monitor levels of questioning.
- Focus questions on searching for student understanding. Remove emphasis from right or wrong answers. Low-level questions do not give a good picture of a student's grasp of a concept.
- Listen carefully to student answers.
- Ask for a paraphrase of what has been said. This improves attentiveness and assesses comprehension.
- Assume that every answer given by a student is meaningful and "correct" to that student. The answers give insight into the student's mind by illuminating misconceptions and misunderstandings.
- Begin lessons with rich questions or problems to engage students and lead to new understanding of important content. Provide a variety of tools to assist mathematical exploration.
- Provide multiple opportunities for social interaction around mathematics ideas. People construct learning by questioning, discussion, and reflection.
- Allocate time carefully. Make notes from class to class on effective amounts of time for each explanation.
- Increase wait time. An observant teaching partner can assist.
- Model self-questioning by "acting out" your thinking when you approach a problem. "I wonder what I should do next? Maybe I should try __."

*Sutton, J.S. & Krueger, A. (2002). *EDThoughts: What We Know About Mathematics Teaching and Learning.* Aurora, CO: Mid-continent Research for Education and Learning.

Working Definitions for Proficiency Levels from NAEP

Proficiency Level	*A question or assignment <u>may</u> be deemed at this level if:*
Basic	• Question cues, such as the following, are used: recall facts; make simple inferences or interpretations; and demonstrate a rudimentary understanding of terminology, principles, and concepts that underlie the field. • It requires students to identify some parts of physical and biological systems. • It requires students to recognize relationships presented in verbal, algebraic, tabular and graphic forms. • It requires students to answer who, what, where and when types of questions. *Simply stated, questions and assignments that require students to remember information and make simple explanations are at the **Basic Level.***
Proficient	• Question cues, such as the following, are used: use analytical skills, draw reasonable conclusions, or make appropriate conjectures or inferences by applying logical reasoning on the basis of partial or incomplete information. • It requires student to defend ideas and to give supporting examples. • It requires the understanding of algebraic, statistical and geometric and spatial reasoning that is relevant to the field. • It requires algebraic operations involving polynomials; justifying geometric relationships. • It requires the application of scientific and technical principles to everyday situations. • It requires judging and defending the reasonableness of answers or solutions to problems that routinely occur in the real world or chosen technical field. *Simply stated, **Proficient Level** questions and assignments require students to apply and analyze information learned.*
Advanced	• It requires the formulation of generalizations, the synthesis of ideas and the creation of models through probing examples and counterexamples. • It requires students to communicate their ideas and reasoning through the use of concepts, symbolism and logical thinking. • It requires the design and application of procedures to test or solve complex, real-world problems. • It requires written responses that are thorough, thoughtful and extensive. *Simply stated, **Advanced Level** questions and assignments require students to evaluate and create work.*

Bloom's Taxonomy with Sample Question Stems and Sample Assignments

			USEFUL VERBS	SAMPLE QUESTION STEMS FOR ASSESSMENTS	POTENTIAL ASSIGNMENTS AND PRODUCTS
B A S I C	**KNOWLEDGE**	**REMEMBERING**	**tell**	What happened after…?	• List the story's main events
			list	How many…?	• Make timeline of events.
			describe	Who was it that…?	• Make a facts chart.
			relate	Name the…?	• List any pieces of information you can remember.
			locate	Describe what happened at…	
			write	Who spoke to…?	• Recite a poem.
			find	Tell me why…?	• List all the animals in the story.
			state	Find the meaning of…?	• Make a chart showing…
			name	What is it…? Which is true or false…?	• Remember an idea or fact • Question and answer sessions • Workbooks and worksheets • Remember things read, heard, seen • Information searches • Reading Assignments • Drill and practice
	COMPREHENSION	**EXPLAINING**		Write in your own words…?	• Finding definitions
				Write a brief outline…	• Memory games Quizzes
			explain	What do you think could have happened	• Forming relationships (analogies, similes)
			interpret	next…?	• Predicting effects of changes
			outline	Who do you think…?	• Dramatization
			discuss	What was the main idea?	• Peer teaching
			distinguish	Who was the main character?	• Show and tell
			predict	Distinguish between…?	• Estimating
			restate	What differences exist between…?	• Story problems
			translate	Provide an example of what you mean by…?	• Cut out or draw pictures to show a particular event
			compare	Provide a definition for…?	• Illustrate the main idea.
			describe		• Make a cartoon strip showing the sequence of events. • Write and perform a play based on the story. • Retell the story in your own words. • Paint a picture of some aspect of the story you like. • Write a summary of the event. • Prepare a flow chart to illustrate the sequence of events.

			USEFUL VERBS	SAMPLE QUESTION STEMS FOR ASSESSMENTS	POTENTIAL ASSIGNMENTS AND PRODUCTS
PROFICIENT	**APPLICATION**	**APPLYING**	**solve** **show** **use** **illustrate** **calculate** **construct** **complete** **examine** **classify**	Do you know another instance where…? Could this have happened in…? Group by characteristics such as…? What factors would change if…? Apply the method used to some experience of your own…? What questions would you ask of…? From the information given, develop a set of instructions about…? Would this information be useful if you had a…?	• Construct a model to demonstrate how it will work. • Make a diorama to illustrate an important event. • Compose a book about… • Make a scrapbook about the areas of study. • Make a paper-mache map showing information • Make a puzzle game using ideas from the study area. • Paint a mural. • Design a market strategy for your product. • Design an ethnic costume. • Use knowledge from various areas to find solutions
	ANALYSIS	**ANALYZING**	**analyze** **distinguish** **examine** **compare** **contrast** **investigate** **categorize** **identify** **explain** **separate** **advertise**	Which event could not have happened if…? If…happened, what might the ending have been? How was this similar to…? What was the underlying theme of…? What do you see as other possible outcomes? Why did…changes occur? Compare your…with that presented in…? What must have happened when…? How is…similar to…? What are some of the problems of…? What was the turning point in the story? What was the problem with…?	• Role playing/role reversal • Producing a newspaper, stories, etc. • Interviews • Experiments • Solving problems by use of known information • Practical applications of learned knowledge • Design a questionnaire to gather information. • Make a flow chart to show critical stages. • Write a commercial for a new / familiar product. • Review a work of art in terms of form, color, and texture. • Construct a graph to illustrate selected information. • Uncover unique characteristics • Distinguish between facts and inferences • Evaluate the relevancy of data • Recognize logical fallacies in reasoning • Recognize unstated assumptions • Analyze the structure of a work of art, music or writing • Compare and contrast • Construct a jigsaw puzzle. • Analyze a family tree showing relationships.

			USEFUL VERBS	SAMPLE QUESTION STEMS FOR ASSESSMENTS	POTENTIAL ASSIGNMENTS AND PRODUCTS
A D V A N C E D	SYNTHESIS	CREATING	**create** **invent** **compose** **predict** **plan** **construct** **design** **imagine** **improve** **propose** **devise** **formulate**	Design a…to…? What is a possible solution to…? What would happen if…? If you had access to all resources, how would you deal with…? How would you design your own way to…? How many ways can you…? Create new and unusual uses for…? Develop a proposal which would…? How would you compose a song about…? Write a new recipe for a tasty dish?	• Invent a machine to do a specific task. • Design a building. • Create a new product. Give it a name and plan a marketing campaign. • Write your feelings in relation to… • Write a TV show, play, puppet show, role-play, song, or pantomime about… • Design a record, book, or magazine cover for… • Create a language code. • Sell an idea to a billionaire. • Compose a rhythm or put new words to a known melody. • Hypothesize • Write a creative story, poem or song • Propose a plan for an experiment • Integrate the learning from different areas into a plan for solving a problem • Formulate the new scheme for classifying objects • Show how an idea or product might be changed • Prepare a list of criteria to judge a…show.
	EVALUATION	EVALUATING	**judge** **select** **choose** **decide** **justify** **debate** **verify** **argue** **discuss** **determine** **prioritize**	Is there a better solution to…? Judge the value of… Defend your position about… Do you think…is a good or bad thing? Explain. How would you have handled…? What changes to…would you recommend? Are you a…person? Why? How would you feel if…? How effective are…?	• Conduct a debate about an area of special interest. • Make a booklet about 5 rules you value. • Make judgments about data or ideas based on either internal or external conditions or criteria • Judge the logical consistency of written material • Judge the adequacy with which conclusions are supported with data • Judge the value of a work or art, music, writing, by using internal criteria or external standards of excellence • Generate criteria for evaluation • Evaluating one's own products and ideas • Form a panel to discuss a topic. State criteria. • Write a letter to…advising changes needed.

Q-CHART

	is	did	can	would	will	might
Who						
What						
Where						
When						
How						
Why						

Q Chart—the simplest form of a question is in the upper left, or "Who is" such as in "Who is the main character?" The more complex the question the further it moves down and the further it moves right, so that the most complex questions are in the bottom right-hand corner ("How might…")

15 Literacy Strategies Every Teacher Can Implement

1. **Admit Slips –** Students compose a written response to one question at the beginning of class, such as "Which problem was hard for you?" or "What did you learn from your homework?"

2. **Exit Slips –** As students leave class, they give their teacher a slip on which they have responded to questions such as: "What did I learn?" and "What am I confused about?"

3. **Graphic Organizers –** As students read a passage, they outline the main ideas according to the organizational pattern of the text. Venn diagrams can be used, for example, for a passage that is organized by comparison/contrast. As students gain more experience, they select the organizer that matches the organizational pattern. These organizers are also known as mind maps or thinking maps.

4. **KWL Charts –** Used as a pre-reading and note taking strategy, KWL charts have three columns: "What I Know" (before reading), "What I Want to Learn" and "What I Have Learned" (answers to the questions). Students fill in these columns as they read, and class discussion focuses on the columns.

5. **Open-Response Questions –** On each test, students should have at least one open-response question that asks them to explain a process to solve a problem, compare different processes or ideas, analyze the importance of certain ideas, or apply learning. Questions should be scored by a rubric.

6. **Double-Entry or Two-Column Notes –** Students take notes using pages that are divided into two columns. On the left side are the main ideas from reading or a class lecture; on the right are the details. It can also be used as an explanation process. On the left is a sample problem; on the right side are the steps to solve the problem.

7. **Retelling –** Pairs of students are given a reading passage. The first student reads aloud a section of one or two paragraphs. The second student, without looking at the text, summarizes what the first student read aloud. They both look at the text and compare it to their understanding. They reverse roles and continue until they have finished the passage.

8. **Weekly Reflections –** At the end of the week, students write for three to five minutes to reflect on what they did and learned that week. Possible topics include "How I solved a problem," "How I used reading skills to learn this week," "The most valuable thing I learned" and "How I will apply what I learned to a career."

9. **Jigsaw Reading –** Students are divided into groups of four and each student takes a number from one to four. All "number ones" get the same article to read. After reading their article, all those who read the same article — article one, for instance — group together and discuss the main points. They return to their home groups and share the main ideas from all articles. Each group then makes a one-minute presentation to the whole class on the common ideas.

10. **Anticipation Guides –** Students respond to five or six statements that challenge or support preconceived ideas about key concepts. The most effective statements are those about which students have some knowledge, but not necessarily a complete understanding.

11. **RAFT –** Students learn to focus their writing by defining their Role, Audience, Format and Topic. For example: "As a graphic arts student, I am writing a letter to an editorial cartoonist to ask him how he designs his cartoons."

12. **Interactive Reading Guides –** Students use this variation of the study guide to work with a partner or group and to discuss essential ideas while reading. Interactive questions are developed by the teacher, and students brainstorm to connect personal knowledge to a passage. Students make predictions, create visual images, raise questions of their own and make inferences.

13. **Concept Definition Maps –** Students focus on content-specific vocabulary using a graphic organizer that encompasses the key components of a definition: class or category, properties or characteristics, and illustrations or examples. Students are encouraged not only to understand the formal definition of a term, but to integrate their personal knowledge into a definition.

14. **Frayer Model –** Students use the Frayer Model (Frayer, Frederick and Klausmeier, 1969) to record information about a concept. The graphic organizer contains four compartments: essential characteristics, nonessential characteristics, examples and non-examples.

15. **Visual Prediction Guide –** Students use the visual prediction guide (Irvin, 2001) to "read" visual information in texts. The teacher guides students through a text, offering only visual information, and students note information about the form: charts, diagrams or illustrations. Students then create their own visuals to illustrate text.

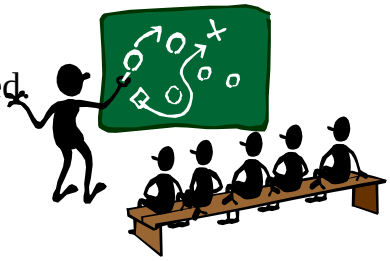
Strengthening Numeracy Plan of Action

Directions: Use the following checklist to plan and implement several key learning ideas from the last two days. Please be prepared to report reflections on teaching, student outcomes and reflections to the large group at our next session.

Part I: Identify five (5) projects/lessons that will be taught prior to the March workshop:

Approx. date taught	Lessons subject/project focus
1.	
2.	
3.	
4.	
5.	

Review the techniques practiced during this training. Use the chart below to record the expected outcomes for each lesson (total of five) developed for the next training session in March.



Planning Check List: Place a check as each aspect is accomplished.

Lesson/Project #	#1	#2	#3	#4	#5
Lesson planning that:					
…reflects *Cycle of Learning* stages					
…reflects the seven elements of a math-enhances lesson					
…includes related contextual problems					
…includes one of the recommended tools to strengthen student understanding					

See you in March! Look forward to learning about your lesson work! ☺